United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

Research Paper
PNW-RP-406

April 1989

Deriving Local Demand for Stumpage From Estimates of Regional Supply and Demand

Kent P. Connaughton, Gerard A. Majerus, and
David H. Jackson

Authors

KENT P. CONNAUGHTON is a research forester, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, P.O. Box 3890, Portland, Oregon 97208. GERARD A. MAJERUS is a regional economist, U.S. Department of the Interior, Bureau of Land Management, Airport Road, Lewiston, Montana 59457. DAVID H. JACKSON is a professor, School of Forestry, University of Montana, Missoula, Montana 59812.

Abstract

Connaughton, Kent P.; Majerus, Gerard A.; Jackson, David H. 1989. Deriving local demand for stumpage from estimates of regional supply and demand. Res. Pap. PNW-RP-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

The local (Forest-level or local-area) demand for stumpage can be derived from estimates of regional supply and demand. The derivation of local demand is justified when the local timber economy is similar to the regional timber economy; a simple regression of local on nonlocal prices can be used as an empirical test of similarity between local and regional economies. Three local demand relations can be derived: (a) the relation between local quantity demanded, regional stumpage price, and other variables affecting supply and demand; (b) the relation between local quantity demanded, local stumpage price, and other variables affecting supply and demand; and (c) the relation between local quantity demanded, nonlocal stumpage price, and other variables affecting supply and demand. We demonstrate how the variation in local demand can be used to evaluate the reliability of the local demand relation. Examples for four National Forests in Montana illustrate the approach.

Keywords: Demand curves, timber supply and demand, land management planning, forest investment analysis, forest economics.

Summary

Information on how the quantity of stumpage demanded can be expected to vary with respect to changes in stumpage price can be important to land managers because price changes can influence the economic efficiency and desirability of public and private timber programs. One approach to measuring the demand for stumpage within a local area or National Forest is to derive the local demand relation from estimates of the supply and demand for stumpage for a larger region (one that includes the local area). This approach is only justified when the local timber resource and processing industry are similar to the regional resource and industry. A first step in deriving local demand, therefore, is to assess the similarity between the local timber economy and the region's timber economy.

A simple quantitative test of similarity is based on the results of the regression of local stumpage price on nonlocal stumpage price. When local stumpage price is statistically related to nonlocal stumpage price, the derivation may be justified. Further, if there is a significant correlation, the regression results can be used to derive three different local demand relations: (a) the relation between local quantity demanded, regional stumpage price, and other variables affecting supply and demand; (b) the relation between local quantity demanded, local stumpage price and other variables affecting supply and demand; and (c) the relation between local quantity demanded, nonlocal stumpage price, and other variables affecting supply and demand. Estimates of the variation in local demand, its standard error, and percent standard error can then be used to assess the absolute and relative reliability of local demand. The derivation procedures are applied to four National Forests in Montana to illustrate our methods. The derivation of local demand was justified for three of the Forests; the local demand relations for two of the three were sufficiently reliable that the local demand relation could be used for planning purposes.

Contents

Introduction

Stumpage-price information is needed for measuring the benefits of silvicultural investments and developing and evaluating land management alternatives. A knowledge of stumpage demand—the relation between price and the quantity of stumpage that purchasers would be willing to buy during any specified period—can be crucial for correctly measuring stumpage prices. Because stumpage prices are determined through the interaction between supply and demand, Federal and other public agencies can affect both public and private stumpage prices by changing the supply of public timber. Analysts' knowledge of supply, unfortunately, is usually better than their knowledge of demand (Krutilla and others 1983). This paper shows how to measure the demand for stumpage on a National Forest or within a specified local area when the analyst has knowledge of the regional demand and supply for stumpage.

The demand for stumpage is derived from the demand for wood products and is affected by the factors that influence the performance of the wood products industry (Gregory 1972, Haynes 1977). These concepts mean that stumpage demand is a function of stumpage price, product prices, other (nontimber) costs of production, processing technology, and other variables affecting the wood-products industry. Haynes and others (1981) provide further background on the terminology and concepts of the demand for stumpage.

In the next section, we briefly review the development of regional demand and supply estimates—the starting points from which local demand relations are developed. The discussion then turns to an easily applied test to help the analyst decide whether or not the derivation of local demand from regional demand and supply is justified. We then develop procedures for deriving local demand from estimates of regional supply and demand. The derivation depends on both the historical proportion of total regional harvest originating from local and nonlocal sources and the relation between local and nonlocal prices. The derivation allows the analyst to account for differences between local and nonlocal stumpage prices. Having derived local demand, we discuss an evaluation of the reliability of local demand. Finally, we provide examples of how the suggested procedures were applied to four National Forests in Montana.

Our approach to the derivation of local demand can be used by analysts, forest economists, and planners in both the public and private sectors. Haynes and others (1981) and Connaughton and Haynes (1983) recognized the need for the methods set forth in this paper: both noted that regional stumpage demand was related to local demand, but that the nature of the relation was not understood. This paper complements Connaughton and others (1988) who evaluate the sensitivity of regional demand estimates to four specifications of regional supply and two measures of stumpage prices for timber harvested on private forest land.

Regional Demand and Supply: The Starting Points for Local Demand

Our procedures required that two equations—one for stumpage demand and one for stumpage supply—be estimated for a region that included the forest or local area of interest. Majerus (1982), Adams (1983), and Connaughton and others (1988) describe how regional supply and demand relations can be statistically estimated with time-series data. The region of analysis is chosen so that very little timber crosses the region's boundaries. A multiequation, spatial model is necessary if the region of analysis is too small and significant flows of timber cross its boundaries.

Prices are assumed to be determined by the simultaneous equilibrium of demand and supply. Demand and supply relations, therefore, must be simultaneously estimated to avoid the biases in statistical estimates that would otherwise result if ordinary-least-squares were used to estimate supply or demand.

Other procedures can be used to develop regional demand and supply relations for stumpage. For example, Haynes and others (1981) report projections of stumpage demand that are based on simulations of the U.S. timber economy made with the timber assessment market model (Adams and Haynes 1980). Their projections show the demand for stumpage, by decade, to the year 2030 for the USDA Forest Service administrative Regions; these projections were prepared pursuant to requirements of the Forest and Rangeland Renewable Resources Planning Act of 1974.

The quantity of stumpage demanded within the region, Q_d, can be expressed as

$$Q_d = f(P_s, P_p, C) ; \tag{1}$$

where

P_s = stumpage price,
P_p = product price, and
C = conversion costs.

Economic theory suggests the following hypotheses: (a) quantity demanded is inversely related to stumpage price ($\partial Q_d/\partial P_s<0$); (b) quantity demanded is directly related to the price of manufactured wood products ($\partial Q_d/\partial P_p>0$); and (c) quantity demanded varies inversely with respect to the costs of conversion, or the costs that will be incurred as standing timber is converted to manufactured wood products. Connaughton and others (1988) provide further details on the concepts and difficulties that analysts can expect as they estimate equation (1).

The quantity of stumpage supplied within the region, Q_s, can be expressed as

$$Q_s = f(P_s,P*,S_p) ; \tag{2}$$

where

P_s = current stumpage price,
$P*$ = future stumpage prices, and
S_p = current inventory.

Economic theory suggests the following hypotheses: (a) quantity supplied is directly related to the current price of stumpage ($\partial Q_s/\partial P_s>0$), (b) quantity supplied is inversely related to expected future prices ($\partial Q_s/\partial P*<0$), and (c) quantity supplied is directly related to the size of current inventory ($\partial Q_s/\partial S_p>0$). Again, Connaughton and others (1988) develop the concepts and discuss the difficulties of statistically estimating the supply relation. For example, expectations for future stumpage prices are not observable.

The average stumpage price for the region is a key variable in both the demand and supply equations. For the estimation of regional supply and demand, Majerus (1982), Adams (1983), and Connaughton and others (1988) view stumpage as a relatively homogeneous factor of production. Realistically, however, stumpage varies by species, location, ownership, and other characteristics affecting its conversion costs, accessibility, and attractiveness to purchasers.

We viewed regional stumpage price as an average price across all local areas and owners in the region. In this way, we were able to build a single, aggregate measure of stumpage price from the disparate prices for stumpage within a region. The derivation of local demand from regional supply and demand recognized, however, that local stumpage prices were likely to differ from nonlocal prices because of location, logging practices, access, species differences, and other factors.

Conceptually, therefore, regional stumpage price was

$$P_s = (1/V) \sum_i V_i P_{si} ; \qquad (3)$$

where

P_s = regional stumpage price,
V = total timber harvest in the region,
V_i = timber harvest from the i-th local area, and
P_{si} = average stumpage price for the i-th local area.

Haynes and others (1981) point out that stumpage prices for individual National Forests, P_{si}, are actually weighted averages of the prices paid for timber on individual timber sales (the weights are the volume of timber on the individual sale divided by the total volume for the management unit). The prices paid for individual timber sales vary by the characteristics of the timber, the characteristics of the processing industry, and the degree of competition among timber purchasers.

Connaughton and others (1988) note that the prices paid for private timber are unobservable and likely are different from the prices paid for public timber because of differences in the contractual arrangements under which the rights to harvest public and private timber are sold. A proxy for regional price is necessary in such cases. They use two proxies for regional stumpage price: (a) the price paid for timber cut on the National Forests (cut price) in the region and (b) a weighted average of cut price and a proxy for private price, which was measured from components of the Forest Service appraisal system as the difference between the value of wood products produced in the region (log scale) and the average regional costs of conversion from logs to wood products. In the examples that follow, we used cut price as a proxy for regional stumpage price.

Methods: Is the Derivation of Local Demand Appropriate?

The appropriateness of deriving the local demand relation for use in local analysis is a matter of judgment—the greater the similarities between the local and regional timber economies, the more applicable regionally adjusted demand and supply will be to a local-area analysis. One should not proceed solely because the Forest or local area of interest is in the region for which demand and supply estimates are available.

We encourage analysts to carefully review the similarities and differences between the local and regional timber economies. Three aspects of the local and regional timber economies should be reviewed: (a) the characteristics of the timber resource, (b) the characteristics of the processing industry, and (c) the markets served by the processing industry. No absolute rules exist for determining when dissimilarities in one or more aspects should preclude derivation of local demand. The following ideas, however, may help analysts think critically about the appropriateness of adjusting regional curves to the local level.

First, if the local species mix is dramatically different from the regional species mix, then the regional demand relation will not accurately reflect the true local demand relation unless the local and nonlocal species can be assumed to be substitutes for one another in the marketplace. Second, if the structure of the local industry includes few timber purchasers, a single type of mill technology, and timber is purchased usually without competition, then this local situation will not be accurately represented by demand and supply relations for a region characterized by many purchasers, wide variation in processing technologies, and aggressive competition for timber. Third, if the markets served by local processors are different from the markets served by the rest of the region's processors, then derivation is questionable because the macroeconomic factors that affect the region's demand and supply relations may be different from the factors that affect the local relations.

One would not expect to find a perfect match between the local and regional timber economies because of location, variation in site and timber characteristics, variation in the costs of production, and differences in industry structure. To provide supplemental information on the similarities between the local and regional timber economies, we partitioned the region of analysis into local and nonlocal components and estimated the following regression with ordinary-least-squares:

$$P_{slt} = \gamma_0 + \gamma_1 P_{snlt} + \varepsilon_t ; \qquad (4)$$

where

P_{slt} = local stumpage price (deflated) in year t,
P_{snlt} = nonlocal stumpage price (deflated) in year t,
γ_0, γ_1 = parameters to be estimated, and
ε_t = error term.

If γ_1 was significantly greater than zero ($\alpha = 0.05$), then we concluded that local and nonlocal prices were positively correlated. We expected a positive correlation between local and nonlocal prices whenever the processing industries in the two areas were similar, logs flowed between local and nonlocal economies, or when the processing industries in the two economies served the same markets. In the following section, we use the estimation results of equation (4) to account for the differences between regional and local stumpage prices.

We caution that useful results from equation (4) do not assure the reliability of local demand even if the results indicate that the derivation of local demand is justified. We postpone the discussion of the reliability of local demand relations to a later section.

Methods: Deriving Local Demand From Regional Supply and Demand

Our procedures allowed the derivation of three different local demand relations. The first demand relation—between local quantity demanded, regional stumpage price, and other variables affecting regional supply and demand—was calculated with the procedures used by Majerus (1982) and Adams (1983). The procedure defined local demand as the excess demand or the difference between regional demand and nonlocal supply. Nonlocal supply was defined as the nonlocal share of the region's harvest multiplied times the regional supply relation.

The first local demand relation was further manipulated to derive two other local demand relations; the derivation of the second and third demand relations was based on the results of equation (4). The second local demand relation expressed local quantity demanded as a function of local stumpage price and variables that affect regional demand and supply. The third demand relation had local quantity demanded as a function of nonlocal price and other variables that affect regional supply and demand. Note: The third relation is unconventional because it describes the relation between a particular good (local stumpage) and the price of a closely related good (the price of nonlocal stumpage). Though we continue to refer to the third relation as a demand relation, it really measures the shifts in local quantity demanded that can be expected with changes in nonlocal price.

The second relation is likely to be more useful than the other two demand relations because it recognizes both local prices and quantities. The third demand relation would be applicable wherever analysts are charged with looking at market effects on nonlocal timber economies. We discuss separately the derivation of each of these relations.

The Relation Between Local Quantity Demanded and Regional Stumpage Price

The relation between local quantity demanded, regional stumpage price, and other variables that affect regional supply and demand was based on the model of excess demand, or the demand remaining after nonlocal supply was subtracted from regional demand (Majerus 1982, Adams 1983). Symbolically,

$$q_d = Q_d - Q_{snl} \; ; \qquad (5)$$

where

q_d = demand for local stumpage,
Q_d = regional demand for stumpage, and
Q_{snl} = nonlocal supply of stumpage.

We further defined Q_{snl} as regional supply multiplied by the nonlocal market share of the region's harvest. Symbolically,

$$Q_{snl} = mQ_s \; ; \qquad (6)$$

where

m = nonlocal share of the region's timber harvest and
Q_s = regional stumpage supply relation.

When equation (6) is substituted into equation (5), local demand is equal to

$$q_d = Q_d - mQ_s \; ; \qquad (7)$$

from equations (1) and (2), we concluded that local demand is a function of regional stumpage price and other variables. Majerus (1982) and Adams (1983) conclude their derivation of local-level demand with equation (7). The relation that is likely to be of greater interest to analysts, however, is between the quantity demanded locally, **local** stumpage price, and other variables. This last relation is developed in the next section.

Time subscripts could have been included in equations (5), (6), and (7) to signify that current and future demand at the local level will depend on the current and future course of variables that affect regional demand and supply. In a later section, we discuss the philosophy and technical difficulties of projecting the demand relation into the future.

Although we chose the average historical, nonlocal market share over the period 1962-80 to represent m for the examples included later in this paper, a different procedure might have been used to quantify market share. For instance, the market share variable could be projected to allow for future fluctuations in local and nonlocal harvest; we did not do so, however, because such information may not be available to the analyst.

Connaughton and others (1988) provide four different specifications of total regional supply Q_s. Each varies according to the variables thought to describe the supply of timber regionally. Any of the four methods could be used to model regional supply; our example results were calculated by assuming that public and private timber supply were a function of the current period stumpage price, total stock of timber on private commercial forest land in Montana, and the level of the National Forest timber sales program.

The Relation Between Local Quantity Demanded and Local Stumpage Price

The estimated coefficients of equation (4) allowed us to modify equation (7) so that it quantified the relation between local quantity demanded, local stumpage price, and other variables. The modification required regional stumpage price be expressed as the volume-weighted average of local and nonlocal stumpage price—a procedure similar to the one suggested by Haynes and others (1980) for adjusting differences between local and regional prices of individual species.

The first step in the derivation of the relation between local quantity demanded and local stumpage price was to express regional stumpage price, P_s, as the volume-weighted average of local and nonlocal stumpage prices; the volume weight for nonlocal price was assumed to equal m, the nonlocal proportion of total regional harvest, and the volume weight for local price was 1 - m. Symbolically,

$$P_s = mP_{snl} + (1 - m)P_{sl} \; ; \qquad (8)$$

where

P_s = regional stumpage price,
P_{snl} = nonlocal stumpage price,
P_{sl} = local stumpage price, and
m = nonlocal share of regional harvest.

The estimated coefficients of equation (4) allowed us to relate local and nonlocal stumpage prices:

$$P_{sl} = \gamma_0 + \gamma_1 P_{snl}$$

or

$$P_{snl} = (P_{sl}/\gamma_1) - (\gamma_0/\gamma_1). \qquad (9)$$

Equation (9) was then substituted into equation (8) to express regional average stumpage price as a function of local price:

$$P_s = [(m/\gamma_1) + (1-m)]\, P_{sl} - m(\gamma_0/\gamma_1). \qquad (10)$$

Once we had expressed regional stumpage price in terms of local price, we were able to express regional supply and demand (in equation 7) as a function of local price, the estimated parameters of equation (4), nonlocal market share (m), and the other variables in equations (1) and (2) that affect regional demand and supply.

We assumed the estimated coefficients of equation (4) were constant at all levels of local and nonlocal quantities. Changes in the local quantity of timber supplied, therefore, would affect prices throughout the region but would leave the estimated coefficients in equation (4) unchanged. This assumption implied that (a) the estimated coefficients reflected stumpage prices that were determined in competitive markets by knowledgeable buyers, and (b) the price differences between local and nonlocal prices captured persistent, qualitative differences between local and nonlocal stumpage and stumpage markets. For example, differences in logging or other production costs would be embedded in the differences between local and nonlocal stumpage prices, and these differences in costs would persist so that the coefficients of equation (4) would be unchanged.

Several relations were possible when γ_1 was significantly greater than zero: (a) when local and nonlocal prices were equal, γ_1 was equal to one, and the intercept term, γ_0, was equal to zero; (b) when the local price was a constant proportion of nonlocal price, γ_1 was a positive number greater than zero, and g0 was equal to zero; (c) when local and nonlocal prices differed by a constant, γ_0 was not zero, and γ_1 was equal to one; and (d) when local and nonlocal prices differed by a constant and were a constant proportion of one another, then γ_0 was not zero, and γ_1 was greater than zero.

We developed the third demand relation, the relation between local quantity demanded and nonlocal stumpage price, by using the same general procedure as for the second demand relation. First, we substituted equation (9) into equation (8) and solved equation (8) for P_s in terms of P_{snl},

$$P_s = [m + (1-m)\gamma_1] P_{snl} + \gamma_0(1-m). \tag{11}$$

We substituted equation (11) into the regional demand and supply relations that were parts of equation (7) to complete the derivation of local demand in terms of nonlocal stumpage price.

Again, the application of this procedure required the assumption that the estimated coefficients of equation (4) remained unchanged over all changes in local and nonlocal harvest levels.

This section is optional and is intended for those who wish to gain greater insight into the relation between regional and local demand. Specifically, the slopes of the demand curves associated with the regional demand relation and each of the local demand relations are compared.

When the differences between local and nonlocal prices are recognized, two of the local demand curves can have the same slope, be steeper, or be less steep than the regional demand curve. The comparisons depend on the assumption that the relation between local and nonlocal price (equation 4) is valid over the range of prices and quantities relevant to the analysis. If this condition is violated, the comparisons do not apply.

The demand curve is the relation between stumpage price and quantity (Haynes and others 1981). The slope of the demand curve measures the change in stumpage price associated with a one-unit change in quantity demanded. Demand curves are downward (negatively) sloping when price is graphed against quantity demanded because quantity demanded is hypothesized to vary inversely with price.

The slope of the demand curve is the reciprocal of the coefficient that measures the change in quantity demanded per unit change in stumpage price. The coefficient dq_d/dP_s, for example, measures the rate of change of local quantity demanded per unit change in regional stumpage price, and the slope of the associated demand curve is $1/(dq_d/dP_s)$. The steeper the slope of the demand curve, the larger (less negative) is the coefficient measuring a change in quantity price per unit change in price.

For simplicity, we refer to the relation between regional quantity demanded and regional price (equation 1) as the regional demand relation; the regional demand curve, therefore, has the slope $1/(\partial Q_d/\partial P_s)$. We refer to the relation between local quantity demanded and regional price as the first local demand relation; its demand curve has the slope $1/(dq_d/dP_s)$. The second local demand relation is the relation between local quantity demanded and local price; the associated demand curve has the slope $1/(dq_d/dP_{sl})$. The third demand relation is the relation between local quantity demanded and nonlocal stumpage price; its demand curve has the slope $1/(dq_d/dP_{snl})$.

Comparison Between the First Local Demand Curve and the Regional Demand Curve

The first local demand curve is less steeply sloped than the regional demand curve. The slope of the first local demand curve is the reciprocal of

$$dq_d/dP_s \quad = \quad \partial Q_d/\partial P_s - m\partial Q_s/\partial P_s \,,$$

where the slope of the regional demand curve is the reciprocal of $\partial Q_d/\partial P_s$. The comparison between local and regional demand curve slopes follows from the signs of both $\partial Q_d/\partial P_s$ and $m\partial Q_s/\partial P_s$ in the equation for dq_d/dP_s: the former is less than zero, the latter is greater than zero; therefore, the difference between the two (the reciprocal of the slope of the local demand curve) is less than $\partial Q_d/\partial P_s$ (the reciprocal of the slope of the regional demand curve). The local demand curve is, therefore, less steeply sloped than the regional demand curve.

Comparison Between the Second Local Demand Curve, the First Local Demand Curve, and the Regional Demand Curve

The slope of the second local demand curve can either be equal to, greater than, or less than the slopes of either the first local demand curve or the regional demand curve. The comparison between the slopes of the local demand curves depends on the ratio of local to nonlocal prices (γ_1 in equation 4). The comparison between the slopes of the second local and regional demand curves depends on the ratio of local to nonlocal prices, the proportion of total regional harvest that originates nonlocally, and the ratio of $\partial Q_d/\partial P_s$ to dq_d/dP_s. We first compare slopes of the local demand curves.

The slope of the second local demand curve is the reciprocal of

$$dq_d/dP_{sl} \quad = \quad [\partial Q_d/\partial P_s - m(\partial Q_s/\partial P_s)]\,[(m/\gamma_1) + (1-m)].$$

The first term in brackets after the equals sign is dq_d/dP_s; it measures the effect of a unit change in regional stumpage price on local quantity demanded. The second term in brackets is the derivative of P_s with respect to P_{sl} (equation 10) and measures the relation between a change in regional stumpage price and a change in local stumpage price.

If γ_1 equals one, then dq_d/dP_{sl} equals dq_d/dP_s, and the slopes of the corresponding local demand relations are equal. If local price is greater than nonlocal price (γ_1 greater than one), then dq_d/dP_{sl} is greater than dq_d/dP_s, and the demand curve for the former is more steeply sloped than the demand curve for the latter. Finally, if local price is less than nonlocal price (γ_1 less than one), then dq_d/dP_{sl} is less than dq_d/dP_s, and the first demand curve is not as steep as the second.

.We now turn to the comparison between the slope of the second demand curve and the slope of the regional demand curve. We demonstrate that the slope of the former can be greater than, equal to, or less than the slope of the latter.

We first look at the conditions under which the slope of the second local demand curve is greater than the slope of the regional demand curve. This condition implies

$$dq_d/dP_{sl} > \partial Q_d/\partial P_s \text{ or}$$

$$[\partial Q_d/\partial P_s - m(\partial Q_s/\partial P_s)][(m/\gamma_1) + (1-m)] > \partial Q_d/\partial P_s.$$

The first term in brackets on the left side of the inequality is less than zero and is also less than $\partial Q_d/\partial P_s$. This inequality can be manipulated so that

$$[(m/\gamma_1) + (1-m)] < (\partial Qd/\partial Ps)/[\partial Qd/\partial Ps - m(\partial Q_s/\partial Ps)].$$

The term on the right side of the above inequality will usually be a positive fraction and cannot be larger than one. This implies that γ_1 must be greater than one—local price must be greater than nonlocal price—for the local curve to be more steeply sloped than the regional curve.

The local curve will not always be more steeply sloped than the regional curve when local price is greater than nonlocal price because the comparison between slopes depends additionally on m and the ratio on the right side of the inequality. These additional restrictions make it difficult for the second demand curve to be more negatively sloped than the regional demand curve. For example, if the m equals 0.95 and the ratio on the right side of the inequality is equal to 0.5, γ_1 would have to be greater than (an unlikely) 2.1 for the local demand curve to be more negatively sloped than the regional demand curve.

The conditions under which the local demand curve is not as steep as the regional demand curve are similarly developed. These conditions require

$$[\partial Q_d/\partial P_s - m(\partial Q_s/\partial P_s)][(m/\gamma_1) + (1-m)] < \partial Q_d/\partial P_s, \text{ or}$$

$$[(m/\gamma_1) + (1-m)] > (\partial Q_d/\partial P_s)/[\partial Qd/\partial Ps - m(\partial Q_s/\partial P_s)].$$

The ratio on the right side of the second inequality is the same ratio encountered previously—its value will be less than or equal to one. The inequalities will be satisfied when γ_1 is less than one, or whenever local price is less than nonlocal price. The condition will sometimes be satisfied when γ_1 is greater than one; the exact conditions depend on m and the magnitude of the ratio on the right side of the inequality.

Finally, the unlikely case in which the slope of the second local demand curve is equal to the slope of the regional demand curve requires

$$[(m/\gamma_1) + (1-m)] = (\partial Q_d/\partial P_s)/[\partial Q_d/\partial P_s - m(\partial Q_s/\partial P_s)].$$

This condition is most likely to be fulfilled when γ_1 is less than one because the ratio on the right side of the equality will usually be less than one.

Comparison Between the Third Local Demand Curve, the First Two Local Demand Curves, and the Regional Demand Curve

This comparison is the opposite of the comparisons for the second local demand curve except that when γ_1 equals one, all three local demand curves have the same slope. When γ_1 is greater than one, the slope of the third local demand curve will be less steep than the slopes of the first and second local demand curves and the regional demand curve. When γ_1 is less than one, the slope of the third local demand curve will be steeper than the slope of the first and second demand curves; the slope of the third demand curve may also be greater than, equal to, or less than the slope of the regional demand curve, depending on whether

$$[m + (1 - m)\gamma_1]$$

is greater than, equal to, or less than

$$(\partial Q_d/\partial P_s)/[\partial Q_d/\partial P_s - m(\partial Q_s/\partial P_s)].$$

The development of these conditions parallels the development of similar conditions for the second local demand curve.

Methods: Evaluating the Reliability of the Local Demand Relations

How reliable are local demand relations? No single answer to this question exists. We urge analysts to look carefully at three measures of statistical precision: (a) the standard error of the coefficient in the regional demand curve that measures the change in quantity demanded per unit change in stumpage price, (b) the standard error of the coefficient in the regional supply curve that measures the change in quantity supplied per unit change in stumpage price, and (c) the percent standard error of the quantity of stumpage demanded locally. The first two measures help the analyst assess the reliability of the fundamental building blocks of equation (7), and the third measure assesses the reliability of the local-level demand relation.

Because they determine the slope of the local demand curve, the coefficients on stumpage price in the regional demand and supply curves are important to analysts. If the price coefficient in the regional demand curve is not statistically significant, then empirical evidence does not support the hypothesis, drawn from economic theory, that the regional demand curve is negatively sloped. More data may help increase the level of precision. When the coefficient on stumpage price in the demand equation is not significantly less than zero, then the analyst must decide whether or not to use the coefficient as computed or to assume that the coefficient is actually equal to zero. In the former case, the analyst implicitly assumes that the coefficient is accurate but without statistical precision; in the latter case, the analyst assumes that the estimated coefficient is neither accurate nor precise. Other information, including theory and empirical evidence, may help analysts assess the accuracy of coefficients and whether or not the coefficients have acceptable levels of statistical precision.

Similar suggestions apply to the regional supply relation. If the coefficient on stumpage price in the regional supply relation is not significantly greater than zero and the coefficient on stumpage price in the regional demand curve is significantly less than zero, then the analyst may wish to assume that the slope of the local demand curve is equal to the slope of the regional demand curve. That is, the analyst would assume that $\partial Q_s/\partial P_s = 0$ rather than that the regional coefficient on price in the regional supply curve is accurate but without statistical precision. Again, additional information may help assess the accuracy of the estimated coefficient.

The coefficients on stumpage price in regional supply and demand are subject to error even if they are statistically significant. Analysts may be tempted to use the coefficients without regard to their associated variation. The confidence interval indicates the limits within which the true value of the coefficient lies, unless an event (with known probability) has occurred so that the true value of the coefficient is not included in the confidence interval. One strategy to acknowledge the variation in the coefficient may be to prepare several sets of regional demand and supply relations and to use them to reveal the sensitivity of local-area plans and projects to alternative demand estimates. Slopes of the various demand curves could be chosen so that they are included within an appropriate confidence interval.

The coefficients on stumpage price in the regional demand and supply relations can be expected to vary according to their variables. Connaughton and others (1988) report coefficients on stumpage price in the regional demand curve for Montana that vary by 100 percent from the lowest to the highest depending on the specification of the regional supply; four of the eight estimated coefficients are statistically significant when $\alpha = 0.1$. They report coefficients on stumpage price in regional supply that vary more widely; one of the estimated coefficients has the wrong sign, and five of the coefficients are significant when $\alpha = 0.1$.

Majerus and others (in press) provide a quantitative measure of the variation in local demand. They write the estimated variance of the local quantity demand, var (q_d), as

$$\mathrm{var}\,(q_d) = \frac{1}{\mathrm{d.f.}} \sum_t (\hat{q}_{dt} - q_{dt})^2 ; \qquad (12)$$

where

q_{dt} = quantity harvested in year t,
($\hat{q}_{dt}$ = predicted quantity harvested in year t, and
d.f. = degrees of freedom.

They calculate the predicted quantity harvested by substituting estimates of regional demand and nonlocal supply into equation (7). The standard error of local demand was the square root of equation (12); the percent standard error was equal to the standard error divided by the average quantity harvested over the sample period.

The estimated variance and the standard error of local demand are absolute measures of variation in local demand; the percent standard error is a relative measure of the variation in local demand. Majerus and others (in press) report variances and standard errors that are of the same general order of magnitude for the National Forests in Montana, but the percent standard errors vary much more widely across Forests (from a low of 30 percent for the Forest with the largest harvest to a high of 2,098 percent for the Forest with the lowest harvest). They conclude that for the National Forests with the higher percent standard errors, local demand relations that are derived from regional estimates of demand and supply should not be used. A corollary conclusion is that the adjustment of regional demand and supply to the National Forest level is justified only for the larger Forests in the region—the percent standard errors are so high for all other forests that statistical precision is at an unacceptable level in the local demand relation.

The local-level demand relation will be subject to variation even if the percent standard error is acceptable. Again, the analyst is encouraged to experiment with alternative local-level slopes so that the sensitivity of local plans and projects to the demand relation can be revealed.

Example: Application to Four National Forests in Montana

In this section, we report results obtained when the procedures previously discussed were implemented. The region of analysis was Montana. The problem was to derive stumpage demand relations for the Custer, Beaverhead, Flathead, and Kootenai National Forests. Our first task was to gauge the appropriateness of the adjustment procedures for each Forest. We then turned to the calculation of three demand relations: the relation between (a) local quantity demanded and regional stumpage price, (b) local quantity demanded and local stumpage price, and (c) local quantity demanded and nonlocal stumpage price. Lastly, we evaluated the reliability of the local-level demand relations.

Table 1—Average annual harvest (1962-80) and average annual proportion of total harvest for each National Forest in Montana

National Forest	Average annual harvest	Average annual proportion of Montana harvest
	Thousand board feet	
Beaverhead	15,819	0.0132
Custer	1,958	.0016
Flathead	131,015	.1115
Kootenai	181,185	.1552

The Appropriateness of the Derivation Procedures

The average annual harvest (1962-80) for the four Forests ranged from a low of 1,958,000 board feet for the Custer National Forest to a high of 181,185,000 board feet for the Kootenai (table 1). As a proportion of total harvest from all ownerships in Montana, the Kootenai was the highest of the four and averaged 15.52 percent; the Custer was the lowest and averaged 0.16 percent.

The only means we used to evaluate the appropriateness of adjusting the regional demand and supply curves were the results of estimating equation (4) for each National Forest. In application, analysts will be better served if they use the results of equation (4) to supplement their knowledge of the similarities and dissimilarities between the local and nonlocal timber economies, as described above, to judge the appropriateness of the adjustment procedures.

We used the price paid per thousand board feet of timber harvested on each National Forest (cut price) as our measure of stumpage price, and we assumed that cut price was a suitable proxy for the price paid for private and other public stumpage. In Connaughton and others (1988), we discuss the problems inherent in this assumption and describe an alternative proxy for private-stumpage price. Regional stumpage prices were calculated as volume-weighted averages of all National Forest cut prices. Nonlocal stumpage prices were calculated from equation (9). All prices were deflated with the gross national product (GNP) implicit price deflator.

The results of estimating equation (4), the relation between local and nonlocal prices, are shown in table 2. Much of the variation in local stumpage price was explained by nonlocal stumpage price for both the Flathead and Kootenai National Forests. The results are not surprising because these two forests had the largest average annual harvests of the 10 National Forests in Montana. The coefficient that measured the ratio of local to nonlocal prices, γ_1, was significantly greater than zero ($\alpha = 0.05$) for both Forests; neither constant was significantly different from zero.

The results for the Beaverhead National Forest were not as reassuring: less than one-third of the variation in stumpage prices was explained by nonlocal prices. The coefficient on price, γ_1, was significantly greater than zero ($\alpha = 0.05$); the constant was not significantly different from zero. None of the variation in the Custer's stumpage prices was explained by the regression. The coefficient on price, γ_1, was not significantly different from zero, though the constant was significantly different ($\alpha = 0.05$).

Table 2—Results of the regression of local (Forest) stumpage prices on non-Forest stumpage prices for the National Forests in Montana[a]

National Forest	Regression results			
	γ_0	γ_1	$\bar{R}^2$	Durbin-Watson
Beaverhead	-1.025	0.387*	0.293	0.992**
	(2.634)	(0.133)		
Custer	5.213**	-0.009	-0.054	1.770
	(0.615)	(0.031)		
Flathead	1.728	1.225*	0.816	0.699**
	(2.593)	(0.136)		
Kootenai	1.364	0.896*	0.715	0.689**
	(2.600)	(0.132)		

[a] Standard errors are in parentheses.
* Coefficients significantly greater than zero ($\alpha = 0.05$).
** Durbin-Watson statistic indicates significant first-order autocorrelation in the residuals ($\alpha = 0.05$).

The presence of autocorrelation made the tests of hypothesis (that the coefficients were significantly different from zero) suspect, though the results were consistent with our understanding of the trends in historical prices on the Forests. We concluded that the adjustment procedures were not appropriate for the Custer National Forest. We retained the Beaverhead, Flathead, and Kootenai National Forests in our analysis.

Deriving Local Demand From Estimates of Stumpage Demand and Supply for Montana

For demonstration purposes we chose the model III specification of Connaughton and others (1988) for the demand and supply for stumpage in Montana. Their demand relation follows (standard errors shown in parentheses beneath the coefficients):

$$\underset{(134{,}703)}{Q_d = 1.231 \times 10^6*} - \underset{(4{,}993)}{4{,}110\, P_s} - \underset{(2{,}439)}{7{,}330\, C*} + \underset{(2{,}883)}{4{,}888\, PP*}\,, \tag{13}$$

$$\bar{R}^2 = 0.47, \text{ Durbin-Watson} = 1.650,$$

*Statistically significant, $\alpha = 0.1$;

where

Q_d	=	quantity of stumpage demanded in Montana (thousands of board feet per year),
P_s	=	stumpage price (deflated dollars per thousand board feet),
C	=	conversion costs (deflated dollars per thousand board feet, log scale), and
PP	=	deflated product price index (converted to log scale).

Equation (13) was estimated with two-stage least squares with data from 1962-80. The specification was justified by microeconomic theory: the quantity demanded of a factor of production is a function of the factor's price, product price, other factor costs, and the production technology. The coefficients all had the expected sign, though the coefficient on stumpage price was not significantly less than zero ($\alpha = 0.1$), as hypothesized from microeconomic theory. The other coefficients were statistically significant.

The supply relation for the model III specification of Connaughton and others (1988) follows (standard errors shown in parentheses beneath the coefficients):

$$
\underset{(1.31 \times 10^6)}{Q_s = -2.563 \times 10^6*} + \underset{(3{,}910)}{5{,}781*\,P_s} + \underset{(127)}{346\,I_p*} + \underset{(0.1)}{0.203\,SA*}\,, \tag{14}
$$

$\bar{R}^2 = 0.56$, Durbin-Watson = 1.847,

*Statistically significant $\alpha = 0.1$,

where

Q_s	=	quantity of stumpage supplied in Montana (thousands of board feet per year),
P_s	=	stumpage price (deflated dollars per thousand board feet),
I_p	=	inventory on private land in Montana (millions of cubic feet), and
SA	=	annual volume of timber sold on the National Forests in Montana (thousands of board feet).

Equation (14) was also estimated with two-stage least squares with data from 1962 to 80. The justification for the specification was also theoretical: the quantity supplied (harvested) on both public and private land was a function of the stumpage price, the volume of timber inventory available on private commercial forest land in Montana, and the volume of timber sold by the Forest Service.

The procedure for calculating the relation between quantity demanded on each Forest and regional stumpage price required equations (13) and (14), the regional demand and supply equations, and the market-share information displayed in table 1. We multiplied all the coefficients of the supply relation for Montana by the proportion of total regional harvest that originated nonlocally and then subtracted the result from the regional demand relation. The results for the three Forests are displayed in table 3.

The relation between local quantity demanded and local stumpage price was calculated by substituting the expression of P_s in terms of P_{sl} (equation 10) into equations (13) and (14), multiplying equation (14) by the proportion of regional harvest originating from nonlocal sources, and subtracting the product from equation (13). Only the constant and coefficient on stumpage price were affected by the adjustments. The results are shown in the second and third columns in table 4.

Table 3—Coefficients on variables included in stumpage demand (stumpage price defined as regional average stumpage price) relations for three National Forests in Montana

National Forest	Variables in demand equation					
	Constant	Stumpage price	Product price	Conversion costs	Nonlocal, non-National forest inventory	Nonlocal National Forest timber sales
Beaverhead	3.76×10^6	-9,813	4,888	-7,330	-340.8	-0.20
Flathead	3.51×10^6	-9,247	4,888	-7,330	-306.9	-0.18
Kootenai	3.40×10^6	-8,994	4,888	-7,330	-291.8	-0.17

Table 4—Constants and coefficients on stumpage price for the relation between local quantity demanded and local stumpage price and the relation between local quantity demanded and nonlocal stumpage price

National Forest	Relation between local quantity demanded and local stumpage price		Relation between local quantity demanded and nonlocal stumpage price	
	Constant	Stumpage price	Constant	Stumpage price
Beaverhead	3.76×10^6	-25,129	3.76×10^6	-9,732
Flathead	3.51×10^6	-7,739	3.51×10^6	-9,478
Kootenai	3.40×10^6	-9,880	3.40×10^6	-8,848

The relation between quantity demanded locally and nonlocal stumpage price was calculated in a similar manner; that is, we substituted equation (11) into equations (13) and (14). Local demand was then calculated as the difference between equation (13) and the product of the share of regional harvest that originated from nonlocal sources and equation (14), regional supply. The results are shown in the last two columns of table 4. Again, only the constant and coefficient on stumpage price were affected by the derivation procedures.

Discussion of Results

None of the coefficients that measured a change in local quantity demanded per unit change in stumpage price were greater than the comparable coefficient for the regional demand curve. Equivalently, the regional demand curve was steeper than each of the local demand curves, even though the ratio of local to nonlocal price for the Flathead National Forest was greater than one. In the previous section, we pointed out that if γ_1 was greater than one, the demand curves for the second and third demand relations might be steeper than the regional demand curve.

The coefficients that measured the change in local quantity demanded per unit change in regional stumpage price for the Beaverhead and Kootenai National Forests were greater than the coefficients that measured a change in quantity demanded per unit change in local stumpage price. The situation was reversed for the Flathead National Forest. The coefficients were different because the ratio of local to nonlocal price (γ_1 in equation 4) was less than one for the Beaverhead and Kootenai National Forests, though the ratio was greater than one for the Flathead National Forest. The constant term, γ_0, from equation (4), did not noticeably affect the constant term in either of the demand relations in table 4.

The price elasticity of demand—the percentage change in quantity divided by the percentage change in price—is one characteristic of demand that measures how sensitive prices will be to changes in quantity. If demand is highly elastic, the elasticity will be less than -1, and proportional changes in quantity demanded will be less than the (absolute) proportional change in price. If demand is highly inelastic, elasticity will be greater than -1, and the proportional change in quantity demanded will lead to an even larger proportional change in price. If demand has unitary elasticity then the proportional change in quantity is equal to the proportional change in price.

We calculated the price elasticities of demand for each demand relation for each Forest. By comparison, the elasticity of the regional demand curve (equation 13), evaluated at average regional price and quantity from 1962 to 80, was a highly inelastic -0.06, signifying that a small percentage change in quantity demanded could lead to a much larger percentage change in price. The elasticities for each Forest were evaluated with the coefficients on price; average real regional, local, and nonlocal stumpage prices; and average quantity harvested locally from 1962 to 80. The elasticities are shown in table 5.

None of the demand relations was as highly inelastic as was regional demand. The elasticities for the Beaverhead National Forest indicated that changes in supply would have little effect on regional, local, or nonlocal stumpage price. The result was not surprising because the Forest's contribution to the timber harvest in Montana was relatively small.

Table 5—Price elasticity of demand measuring the percentage change in local quantity demanded for each 1-percent change in local, nonlocal, and regional stumpage price

National Forest	Stumpage price		
	Local	Nonlocal	Regional
Beaverhead	-9.64	-17.11	-11.26
Flathead	-1.37	-2.03	-1.28
Kootenai	-0.96	-1.43	-0.90

The situation was different for the Kootenai and Flathead National Forests. Both Forests could affect local and nonlocal stumpage prices. The Kootenai National Forest could most affect prices, which is not surprising—the Forest contributed the largest share of any National Forest to total harvest in Montana. The elasticity for the relation between quantity demanded and price on the Kootenai was inelastic—the Forest could have an important effect on local price and could exert a strong influence over nonlocal prices.

Assessing Reliability

How do we assess the reliability of the demand relations? The first step is to evaluate the coefficients on the price terms in the regional demand and supply equations. The coefficient on price in the regional demand equation is not significantly less than zero as was suggested by economic theory. Connaughton and others (1988) report, however, similar estimates for the same coefficient with different models of supply and demand in Montana. There is some indication, therefore, that the coefficient is of the proper order of magnitude. Additional data might help increase the precision of the hypothesis tests.

Similar conclusions apply to the regional supply curve, though the coefficient on stumpage price is significantly greater than zero ($\alpha = 0.1$). Again, the order of magnitude appears reasonable given the results of Connaughton and others (1988) for similar models for Montana.

The level of reliability of the local demand relations varies inversely with the percent standard error. The standard errors of the estimates (equation 12) and their associated percent standard errors are reported for each Forest in table 6. Percent standard error is roughly correlated with the size of the Forest's contribution to the Montana timber harvest. The largest percent standard error was for the Beaverhead, the Forest with the smallest harvest, while the smallest percent standard error was for the Kootenai, the Forest with the largest harvest.

The most reliable estimates, therefore, are for the Kootenai; the least reliable, for the Beaverhead. The demand curve slope computed from the coefficients in tables 3 and 4 present a relatively precise picture of the current demand for stumpage on the Kootenai. Accuracy is more difficult to assess, though the building blocks of regional supply and demand appear reasonable.

Table 6—The percent standard error for the estimated quantity demanded for 3 National Forests in Montana

National Forest	Standard error	Percent standard error
Beaverhead	59,577	376
Flathead	64,782	49
Kootenai	63,861	35

Current demand is only one dimension of measuring demand because analysts are typically interested in the future as well. The results for equation (4) suggest that future demand on the Kootenai will follow trends for Montana. Projections of future prices for the State, therefore, might reasonably be used to change the location of the local demand curve in price-quantity space (for example, using the projections of Haynes and others 1981). Alternatively, one would use projections applicable to Montana for the variables in equations (13) and (14) to project both demand and supply.

The estimates for the Beaverhead are so imprecise that it would be unwise to place much confidence in the accuracy of the demand relations. The results for equation (4), however, indicate that the Beaverhead's stumpage prices follow nonlocal trends, so projections of prices in Montana might reasonably be used in conjunction with the assumption of a horizontal-demand curve equals zero ($1/(dq_d/dP_{sl}) = 0$) for analyses on the Beaverhead.

Conclusions

We have demonstrated how analysts might reasonably derive local demand from demand and supply for stumpage in a region. The derivation depends on the relation (correlation) between local and nonlocal prices and the proportion of the region's harvest contributed by the Forest or local area.

Three types of local demand relations can be computed: (a) the relation between local quantity demanded and regional stumpage price, (b) the relation between local quantity demanded and local stumpage price, and (c) the relation between local quantity demanded and nonlocal stumpage price. The first and third demand relations should be useful for an assessment of a Forest's or local area's impact on the nonlocal timber economy. Issues that might be addressed include the effect of National Forest timber sales programs on regional stumpage prices, the prices paid for private and other public stumpage, and the effect on local timber supply changes on nonlocal timber supply.

The second demand relation should be most useful for local efficiency analyses—to evaluate the economic efficiency of silvicultural options and to assess the economic desirability of land management alternatives. The slope of the demand curve for the second demand relation ($1/(dq_d/dP_{sl})$) could be used for harvest scheduling when the objective function is to maximize some measure of economic performance such as present net worth or net social benefit.

The demand relations are subject to error and represent the limit of our knowledge of current demand—little is known of future demand with any great degree of certainty. Analysts are encouraged to experiment with both current and future demand relations to reveal the sensitivity of proposed plans and projects to imprecise estimates of current demand and unforeseen changes in future demand.

Literature Cited

Adams, Darius M. 1983. An approach to estimating demand for National Forest timber. Forest Science. 29(2): 289-300.

Adams, Darius M.; Haynes, Richard W. 1980. The 1980 softwood timber assessment market model: structure, projections, and policy simulations. For. Sci. Monogr. 22. Washington, D.C.: Society of American Foresters. 64 p. Supplement to Forest Science. 26(3): 1980 September.

Connaughton, Kent P.; Haynes, Richard W. 1983. An evaluation of three simplified approaches to modeling the regional demand for National Forest stumpage. Forest Science. 29(1): 3-12.

Connaughton, Kent P.; Jackson, David H.; Majerus, Gerard A. 1988. Alternative supply specifications and estimates of regional supply and demand for stumpage. Res. Pap. PNW-399. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 19 p.

Gregory, G. Robinson. 1972. Forest resource economics. New York: Ronald Press. 548 p.

Haynes, Richard W. 1977. A derived demand approach to estimating the linkage between stumpage and lumber markets. Forest Science. 23:(2) 81-288.

Haynes, Richard W.; Connaughton, Kent P.; Adams, Darius M. 1980. Stumpage price projections for selected western species. Res. Note PNW-367. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 14 p.

Haynes, Richard W.; Connaughton, Kent P.; Adams, Darius M. 1981. Projections of the demand for national forest stumpage by region; 1980-2030. Res. Pap. PNW-282. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 13 p.

Krutilla, J.V.; Bowes, M.D.; Wilman, E.A. 1983. National forest system planning and management: an analytical review and suggested approach. In: Sedjo, Roger, ed. Governmental interventions, social needs, and the management of U.S. forests. Baltimore: The Johns Hopkins University Press for Resources for the Future. p. 207-236.

Majerus, Gerard A. 1982. Econometric estimation of demand and supply curves for timber in Montana, 1962-1980. Missoula, MT: University of Montana. 52 p. M.S. thesis.

Majerus, Gerard A.; Jackson, David H.; Connaughton, Kent P. [In press]. Estimating and interpreting the variation in the local demand for stumpage. Forest Science.

GPO 691-133/82047

Connaughton, Kent P.; Majerus, Gerard A.; Jackson, David H. 1989. Deriving local demand for stumpage from estimates of regional supply and demand. Res. Pap. PNW-RP-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

The local (Forest-level or local-area) demand for stumpage can be derived from estimates of regional supply and demand. The derivation of local demand is justified when the local timber economy is similar to the regional timber economy; a simple regression of local on nonlocal prices can be used as an empirical test of similarity between local and regional economies. Three local demand relations can be derived: (a) the relation between local quantity demanded, regional stumpage price and other variables affecting supply and demand; (b) the relation between local quantity demanded, local stumpage price, and other variables affecting supply and demand; and (c) the relation between local quantity demanded, nonlocal stumpage price, and other variables affecting supply and demand. We demonstrate how the variation in local demand can be used to evaluate the reliability of the local demand relation. Examples for four National Forests in Montana illustrate the approach.

Keywords: Demand curves, timber supply and demand, land management planning, forest investment analysis, forest economics.

Pacific Northwest Research Station
319 S.W. Pine St.
P.O. Box 3890
Portland, Oregon 97208

U.S. Department of Agriculture
Pacific Northwest Research Station
319 S.W. Pine Street
P.O. Box 3890
Portland, Oregon 97208